UNITED STATES DEPARTMENT OF AGRICULTURE
Production and Marketing Administration
Cotton Branch

COTTON TESTING SERVICE

Washington, D. C.
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Contents

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The various cotton fiber and manufacturing tests available on a fee basis under the Cotton Service Testing Act are described herein in order to acquaint cotton breeders, producers, merchants, manufacturers, and others who may utilize the service, with the methods employed in making the tests, and with the significance of the results. A complete list of the tests available and the schedule of fees are shown in a companion publication entitled "Regulations Governing Cotton Fiber and Spinning Tests Under the Act of April 7, 1941."

Location of Laboratories and Procedure of Requesting Testing Services

Testing laboratories are operated by the Cotton Branch at the following locations: Washington, D. C.; Clemson, S. C.; Stoneville, Miss.; and College Station, Tex.

The special equipment required for many of the tests and the high degree of skill required for accurate results have made it advisable to provide a certain amount of specialization at the various laboratories. At present, service tests made by the Fibrograph length tester and the Pressley flat bundle tensile strength tester are performed at the Stoneville, Miss., laboratory. This laboratory also performs fractionation tests to determine the foreign matter content of seed cotton, and gins small lots of seed cotton. All fiber cross-section and grade and staple classifications are made in the Washington laboratory. This laboratory also performs other fiber tests. The laboratory at College Station, Tex., is equipped for carded yarn spinning tests, skein and single strand yarn tests, and for the following fiber tests: Length arrays, fineness, and maturity. The Clemson laboratory also performs the same tests, as well as fabric weaving and combed yarn spinning tests. Both the Clemson and College Station laboratories perform plied yarn, cord, and Shirley Analyzer tests.

The scheduling of tests and the supervision and coordination of the work of the various laboratories are conducted from Washington, D. C. Therefore, where feasible and for most expeditious service, inquiries concerning tests should be addressed to the Washington Office as follows:

Cotton Branch
Production and Marketing Administration
United States Department of Agriculture
Washington, 25, D. C.

1/ This is a revision of a publication entitled "Cotton Fiber and Spinning Testing Service," issued in 1944 by the Office of Distribution, War Food Administration.

The Washington office will notify the person requesting service tests to which laboratory the samples should be sent. If desired, however, requests may be made directly to the laboratory nearest the applicant and test samples sent to that laboratory. Samples for tests to be performed at other laboratories will be prepared and forwarded by the laboratory originally receiving the samples.

All inquiries concerning policies or the broad interpretation of test results should be addressed to the Washington office. Questions concerning specific test results may be addressed to the laboratory preparing the report on such tests.

Selection and Preparation of Samples

Results of the fiber and processing tests can be no more representative of cottons than the samples themselves; therefore the proper size, selection, and preparation of samples are extremely important. The following suggestions relative to the selection and preparation of samples are designed to aid applicants for testing services in obtaining the most reliable results possible:

Size. - 5 ounces or more for fiber tests
5 pounds or more for each carded yarn spinning test
8 pounds or more for each combed yarn spinning test
(When a spinning test on a composite sample representing a mill mix is requested, approximately 10 pounds of cotton should be submitted for each mix.)

Selection. - In view of the high degree of variability found for all measurable properties of cotton within a bale or even within a small sample, it is very important that care be exercised in selecting the fibers that are actually to be tested. Otherwise, the test specimens may not be truly representative, and a false impression will be obtained of the cotton being tested.

When breeders submit samples of seed cotton to be ginned, they should be representative of the breeding block. In other instances where the breeder does his own ginning, the seed cotton should be mixed thoroughly before ginning, and preferably the sample should be drawn from approximately the midpoint in the ginning process. Saw-ginned lint for upland cottons is preferred, as it is not possible to obtain an accurate grade designation for such cotton on roller-ginned samples. Except for comparative purposes, it is inadvisable to submit samples that have been weather damaged, as the lint may no longer be representative of the normal qualities of the seed stock being studied.

Where spinning tests are to be made from commercial bales and other relatively large supplies of lint, the samples should be composed of equal amounts of cotton taken from a number of places in the bale. In

cases where a spinning test sample is to represent a "mix," equal quantities of cotton should be selected from each bale in the mix, unless otherwise desired by the applicant.

Selection of Tests

In making requests for tests, it should be borne in mind that each test is designed to give specific information regarding some phase or phases of cotton quality. Only those tests that will furnish data that may be helpful in explaining the cotton quality problems being studied should be requested. A well planned test will generally yield more useful data on a specific problem and may cost less than a carelessly planned test. Selecting the tests desired is, of course, a matter for the applicant to decide. Helpful suggestions regarding the most suitable tests for solving specific problems may be obtained, however, by writing to the Washington office or to the field laboratories. Requests for such suggestions should outline briefly the purposes for which the service tests are needed and should give any available information regarding the varieties of cotton, place of growth, or other pertinent information. By reviewing pamphlets that are published by the Department of Agriculture to show the spinning and fiber properties of various varieties and growths, the applicant may obtain suggestions that will be helpful in determining the tests that will best serve his purpose.

Description and Interpretation of the Tests

Seed Cotton

Ginning of test samples. (1) 2/ - This test includes the weighing and ginning of sufficient seed cotton to produce from 6 to 10 pounds of lint. The ginning is performed on a saw gin equipped with an extractor cleaner feeder. The lint and seed are both weighed and reported along with the percentage of lint turn-out. When spinning tests are to be made on the lint, the ginning laboratory selects, packages, marks, and ships the test samples to the designated spinning laboratory. If the applicant requests it, the cottonseed will be returned at his expense.

Fractionation of foreign material. (37) - This test provides a means for determining foreign matter content in samples of seed cotton. Care should be exercised to submit a representative sample of seed cotton weighing from 1 to 2 pounds. The sample is given a preliminary preparation by hand to the extent that sticks and hulls are removed before placing the sample in a device developed by the laboratories of the Cotton Branch for making the test. Compressed air is used to agitate the sample in a bell jar, and trash is screened from the discharged air. Results reported show the average percentage of foreign matter in the seed cotton based on three determinations.

2/ Numbers in parentheses refer to test numbers, as shown in the published schedule of tests referred to in the first paragraph on page 1.

Figure 1.--General view of fiber laboratory showing technicians making tests to determine various cotton fiber properties.

Fiber Tests and Their Evaluation

Fiber tests are conducted under standard atmospheric conditions of 70 degrees F. and 65 percent relative humidity, after the samples have been conditioned for 4 hours or more (See figure 1). When samples are handled in the process of testing, an additional 2-hour conditioning period is required before further testing.

Fiber length array. (2) - This test is made with the Suter-Webb fiber sorter (See figure 2). Briefly, a representative 75 milligram sample of cotton is parallelized through a series of combs where the fibers are separated and arrayed according to lengths, as illustrated in figure 3. The different length groups, at 1/8-inch intervals, are measured and weighed for three length arrays and the averages obtained are reported for the upper quartile length, mean length, and coefficient of length variation.

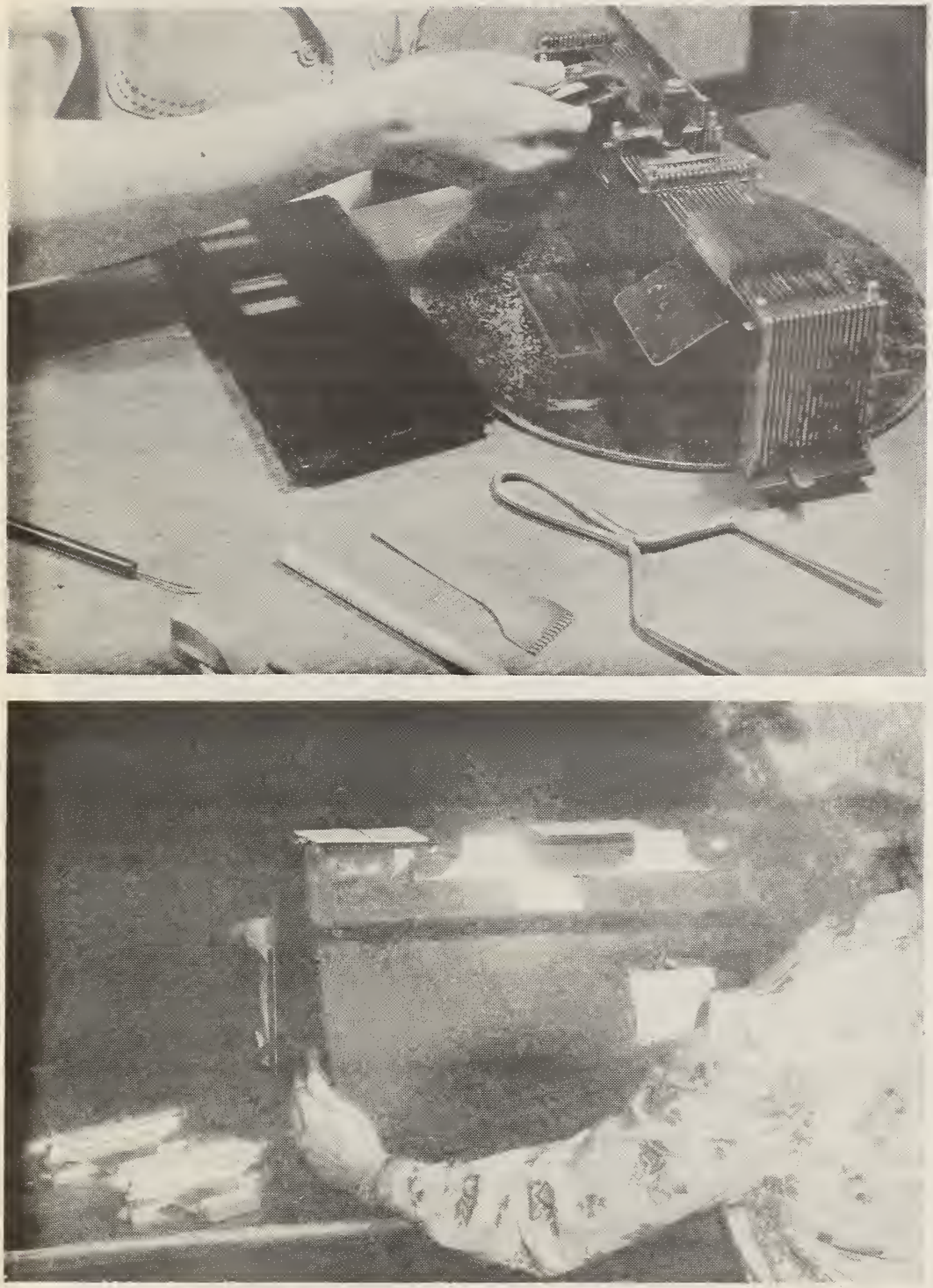

Figure 2.--Illustrating the operation of apparatus for making fiber length analyses: (Top) Suter-Webb fiber sorter and auxiliary equipment; (Bottom) Fibrograph showing an extra set of combs on the left that are ready for inserting into the machine.

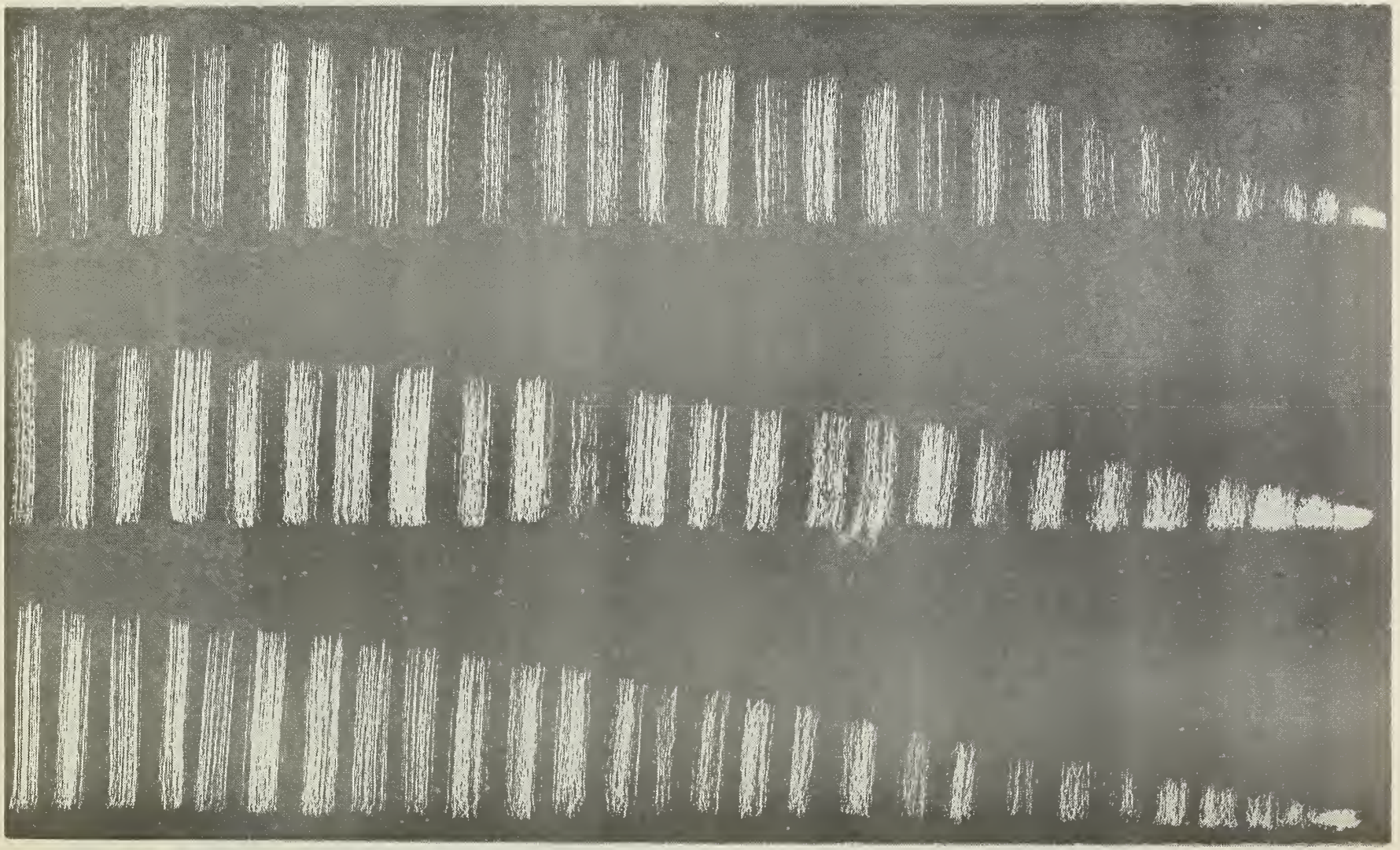

Figure 3.—Fiber length arrays (about actual size) of different cottons illustrating: (Top) A cotton with relatively high length uniformity; (Center) average fiber uniformity; (Bottom) a cotton of irregular fiber length.

The upper quartile length is the length which is exceeded by 25 percent of the fibers by weight in the sample. It is usually closely related to but slightly longer than the classer's staple length designation. Its relationship to that value may vary, however, because of fiber characteristics other than length which may be taken into account by the classer.

The mean length is the average length of all fibers in the sample, as determined from the weight-length data.

The coefficient of length variation is a measure of the variability of fiber length in the sample and represents the standard deviation of the weight-length frequencies expressed as a percent of the mean length. The smaller the figure the more uniform are the fiber lengths. Excessive variation in fiber length tends to increase manufacturing waste, makes processing more difficult, and tends to lower the quality of the product. It is, therefore, considered desirable for a cotton to have a low coefficient of variation. Comparisons between samples may be made according to the following descriptive designations:

Coefficient of fiber length variation	
Below 27	Low variability
27 - 34	Average variability
35 and above	High variability

For those desiring more complete data for the purpose of plotting fiber length array curves or for more detailed study of length distribution, test (2a) has been provided. In addition to the three values reported in test (2), this test includes the percent of fibers by weight in each 1/8-inch length group.

Test (2b) is designed to provide detailed data required in connection with the U. S. Pharmacopoeia standards for purified or absorbent cotton. It involves the preparation of fiber length arrays on the Suter-Webb sorter, and the determination of the percentages of fiber which are: (a) 1/2-inch long and longer, (b) 1/4-inch and shorter in length, and (c) of the intermediate lengths, in keeping with procedures specified in the Second Supplement to the Pharmacopoeia of the United States of America.

Test (2c) is available for determining the upper quartile length, mean length, and coefficient of length variation on samples of manufacturing waste. The significance of these values and other details regarding this test are described under test (2), Fiber length array.

Test (2d) is made on samples of manufacturing waste and the values reported show the upper quartile length, mean length, and coefficient of length variation. In this test the percentage by weight of the fiber in each 1/8-inch group is furnished the applicant in addition to the data reported under test (2c).

Fiber length (Fibrograph). (3 and 3a) - These tests provide measures of fiber length as determined by the Fibrograph which is a photoelectric device for measuring the length and length distribution of the fibers in a sample of cotton (See figure 2).

The "upper half mean length," as determined by this instrument, provides a measure of the average length of all fibers longer than the mean length, expressed in terms of decimal fractions of an inch. Although the "upper half mean length" is closely related to the classer's designation of staple length, it may vary from that value because of fiber characteristics other than length which may be taken into account by the classer. "Mean length" is the average length of the fibers in the sample, excluding those shorter than 1/4-inch. The "uniformity ratio," expresses the relation between the mean length of the fibers and the upper half mean length, and provides a relative measure of the length uniformity of the fibers. The larger the figure reported, the more uniform the fiber length. For practical purposes, comparisons between samples may be made according to the following descriptive designations:

Uniformity ratio	
Above 80	Uniform in fiber length
76 - 80	Average uniformity
71 - 75	Slightly irregular in fiber length
70 and below	Irregular in fiber length

The uniformity ratio as determined from Fibrograph data is not mathematically comparable with coefficient of variation based on the sorter array. The latter is based on the weight of all fibers in the sample, whereas the Fibrograph is based on the number of fibers and disregards fibers shorter than 1/4 inch.

Fibrograph values reported for individual samples are based on five determinations for item (3). In the case of item (3a) where the sample is composed of several subsamples, two determinations are made on each subsample and the results are averaged to obtain representative values for the entire group of subsamples.

Fiber strength. (5 and 5a) - Fiber tensile strength is determined by using a flat bundle Pressley strength tester (See figure 4). In making the test, cotton is hand-combed and parallelized in the form of a flat ribbon about 1/4 inch wide and then is placed in a set of breaking clamps. The fibers are cut to a definite length, broken in the Pressley tester, and then weighed. The quotient obtained by dividing the breaking load in pounds by the weight in milligrams of the fibers affords the strength index. Because of the more general understanding of fiber strength when expressed in terms of tensile strength, that is, the force required to rupture a given cross-sectional area, the index is converted into 1,000 pounds per square

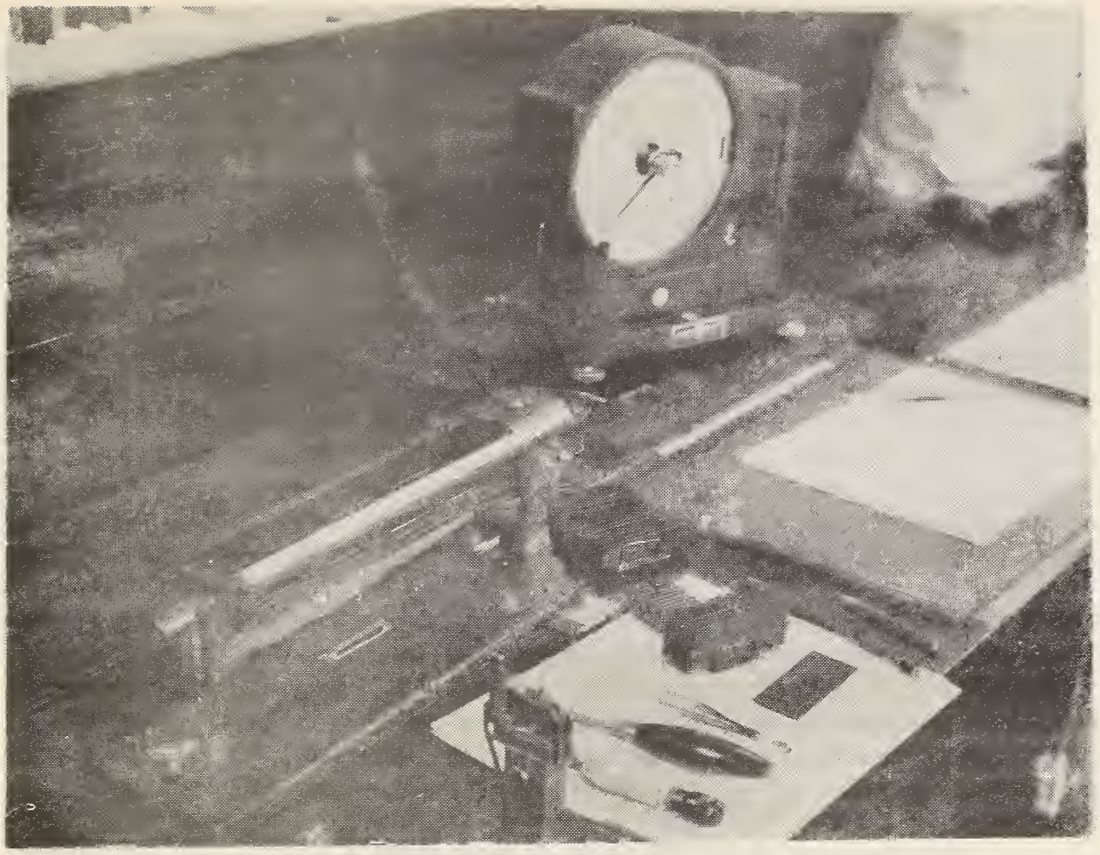

Figure 4.--Pressley strength tester (left foreground), torsion balance, and other auxiliary equipment used in determining the tensile strength of cotton fibers.

inch by applying the following formula: Tensile strength = (10.8116 x strength index) -0.12. Test results reported are based on an average of six breaks, except that in the case of item (5a), when a sample of a variety or lot is composed of several subsamples, two breaks are made on each subsample and the average value for the lot is reported.

Fiber strength is an important factor in determining yarn strength. Cottons with good fiber strength usually give less trouble in manufacturing processes than weak-fibered cottons. The following designations will assist in the interpretation of the test data reported and serve to facilitate comparisons between cottons:

Fiber strength (1,000 pounds per square inch)	
93 and above	Superior
87 - 92	Very strong
81 - 86	Strong
75 - 80	Average
70 - 74	Fair
Below 70	Weak

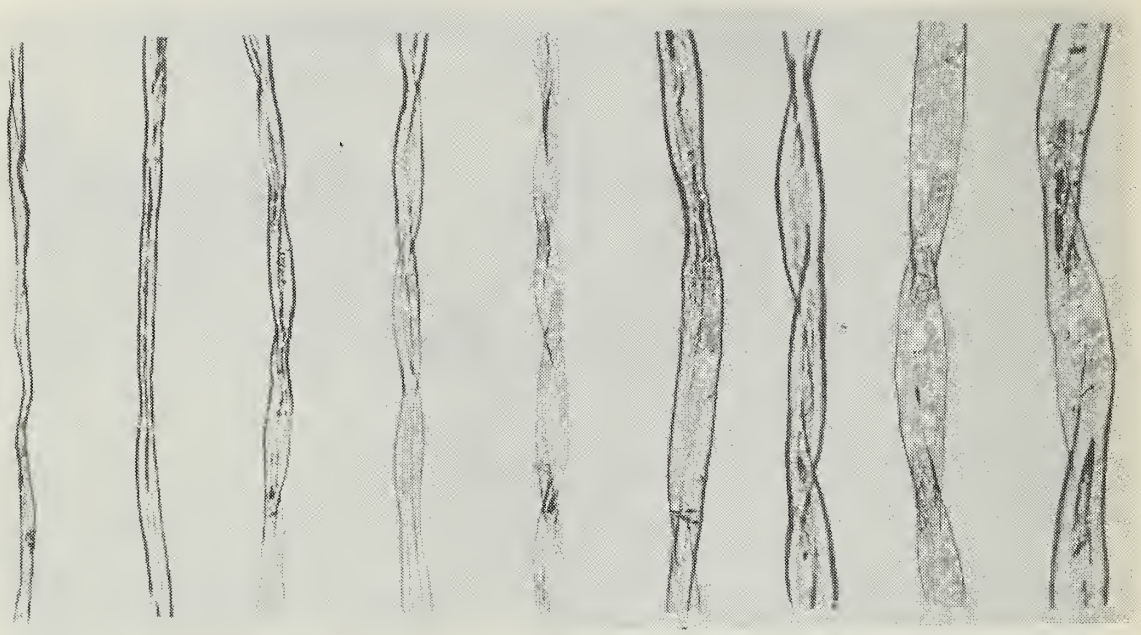

Figure 5.--Reproduction of raw cotton fibers showing gradations in fineness found in American upland cotton (about 230X).

Fiber strength tests were formerly made by the round bundle technique, but that method is no longer recommended to users of the testing service, as the flat bundle method described above has been found slightly more reliable and is made at much lower cost.

Fiber fineness (weight per inch) and maturity. (6) - In making these tests, two fiber-length arrays are first made. For the fineness test, approximately 100 fibers are extracted from each 1/8-inch length array group, and are weighed. The average weight per inch of fiber in the sample is then calculated and expressed in terms of micrograms per inch of fiber. The larger the figure reported the coarser the fibers, and, conversely, the lower the figure the finer the fibers. As a general rule, long cottons are finer fibered than short cottons (See figure 5). Fiber fineness contributes to yarn strength and the importance of this fiber property to yarn strength increases as finer counts of yarn are spun. Very fine fibers, however, tend to increase neppiness and to reduce the rate of processing, so that the desirability of fiber fineness depends on the specific end product or use. For American upland cottons of medium- and short-staple lengths, the following adjective ratings may be applied for purposes of comparisons:

Fiber fineness (Micrograms per inch of fiber)	
Below 3.0	Very fine
3.0 to 3.9	Fine
4.0 to 4.9	Average
5.0 to 5.9	Coarse
6.0 and above	Very coarse

A false impression of inherent fineness is frequently imparted by highly immature cottons, and for this reason a measure of maturity is almost a necessity in evaluating cottons on the basis of their fiber weight. Fiber maturity is determined by examining approximately 100 fibers from each 1/8-inch length group of the array under high-power magnification, to determine the relative thickness of the fiber cell walls after the fiber walls are swollen by applying an 18 percent solution of sodium hydroxide. This swelling of the fiber walls accentuates differences in wall thickness and facilitates the determination of the proportions of thick-walled fibers and thin-walled fibers, which indicate maturity and immaturity respectively. Although thickness of cell wall is to some extent a varietal characteristic, this property varies significantly with growth conditions. Statistical analyses have shown that fiber maturity is a desirable characteristic from the standpoint of low picker and card waste since it ranks second only to grade in this respect. For fine combed yarns, the more mature cottons produce yarns having significantly better appearance grades. Cottons differing in degree of maturity do not dye uniformly. Immature fibers are a source of neps which are also an important factor affecting the appearance of finished fabrics. The following descriptive terms may be applied:

Fiber maturity (Percent)	
Above 84	Very mature
77 - 84	Mature
68 - 76	Average
60 - 67	Immature
Below 60	Very immature

Certain tests are offered in combinations at reduced fees when they can be made in less time than would be required for the individual tests. Combination fiber test (6a), which includes items (2) fiber length array and (6) fiber fineness and maturity, is an example of such a test, since the standard procedure involves the making of length arrays as a basis for fineness and maturity determinations. Another combination test that has been utilized extensively by cotton breeders and mills for evaluating cotton is test item (10). This combination test is composed of items (3) fiber length by Fibrograph, (5) fiber tensile strength (flat bundle), and (6) fiber fineness and maturity.

Fiber cross-section. (7) - In this test a small tuft of fibers is placed in a Hardy-type microtome and a very thin cross-section of fibers is cut. A photomicrograph of the fibers magnified 1,000 times is made to provide a cross-sectional view of the fibers. Measurements are then made of 200 fibers, and from these measurements, the average fiber "diameter" and wall thickness, in microns, and the circularity ratio are calculated. The report shows these values and includes a print of the photomicrograph which is larger but similar in other respects to those shown in figure 6. When additional photomicrographic prints are desired, they may be obtained by requesting test item 7a.

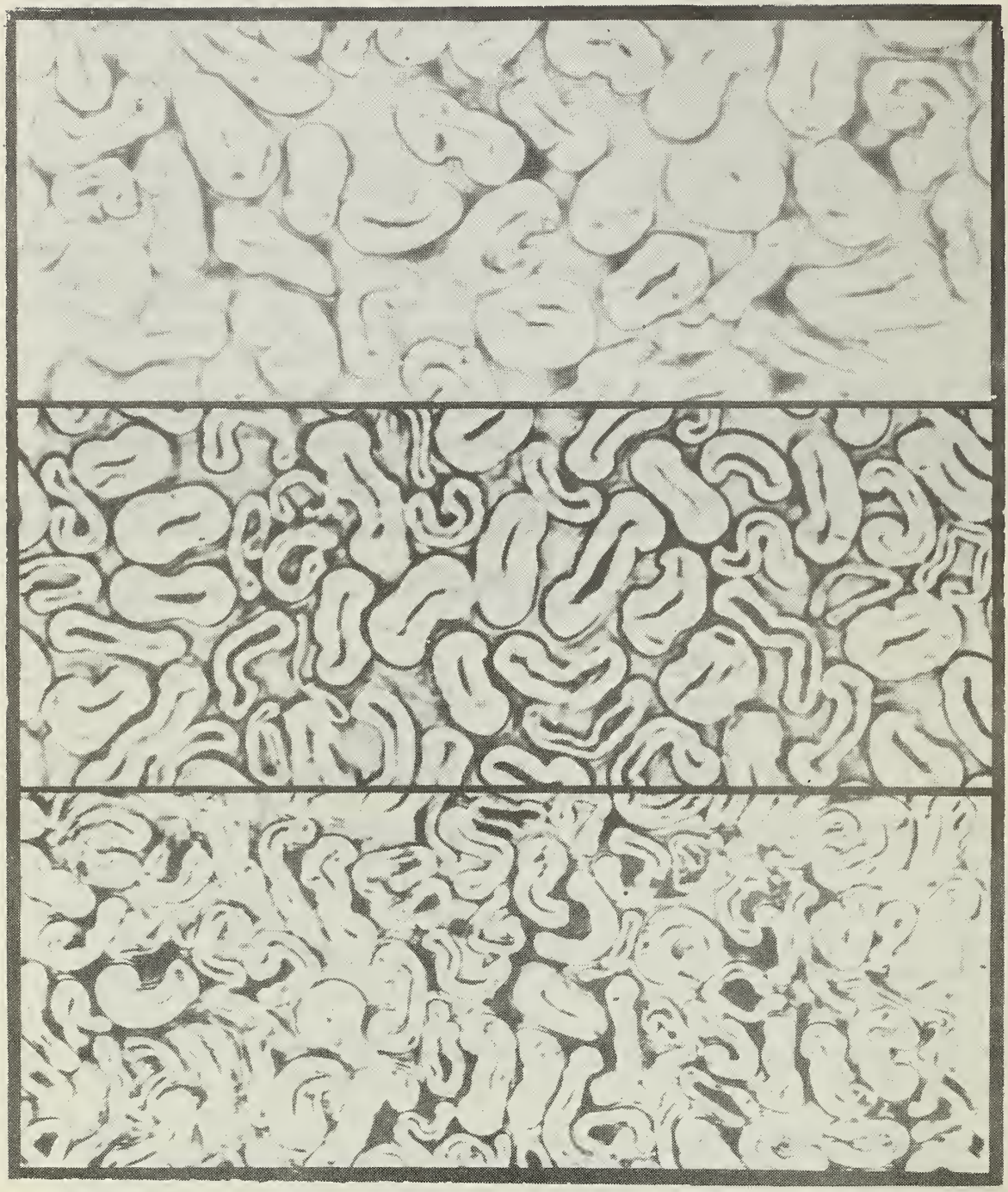

Figure 6.--Photomicrographs of cotton fiber cross-sections showing: (Top) very mature cotton; (Middle) average maturity; (Bottom) very immature cotton fibers (about 1000X).

In these calculations, the diameter of a fiber is assumed to be one-half the sum of the long axis and the short axis of the fiber cross-section. The circularity ratio is the ratio of the long axis to the short axis of the fiber, and the wall thickness is one-half the difference of the over-all width less the lumen width. These measurements, and their coefficients of variation, provide measures of the cross-sectional characteristics not obtainable in any other way.

Classification for grade and staple length. (28) - This classification is made in accordance with usual commercial methods and is based on the Official Cotton Standards for Grade and Staple Length.

Processing Tests and Their Evaluation

In the final anlaysis, the actual results obtained in processing different samples of cotton and testing the resulting yarns provide the most satisfactory basis for evaluating their relative merits. Laboratory equipment and techniques have now been developed to a point where reliable spinning test results can be obtained from small samples of cotton.

Spinning tests (items 11 through 19a) are provided for carded yarns, combed yarns, and combinations of both. In commercial practice, most cottons 1-1/8 inches and longer are manufactured into combed yarns. Although considerable cotton shorter than 1-1/8 inches is used for combed yarns, the major part of it is used for carded yarns. Applicants for spinning tests should indicate in each instance whether a carded test, a combed test, or a combination of the two is desired.

Spinning tests are conducted on commercial-type cotton-manufacturing machinery by use of standardized laboratory procedures and techniques which have been developed to insure reproducible results (See figure 7). The customary manufacturing procedure for carded-yarn spinning tests includes two processes of picking, both of which are performed on a finisher picker, conventional carding, two processes of drawing, one superdraft roving process, and double rovings fed to long-draft spinning frames. The carding process used for medium- and short-staple cottons consists of feeding an 11-ounce lap to a card operated with a nominal cylinder speed of 166 r.p.m. and a doffer speed of 10-1/2 r.p.m., which results in the production of 9.5 pounds of 40-grain sliver per hour. For combed yarn tests on medium staples, the same procedures are used through the carding process. The card sliver is processed through the sliver and ribbon lappers, the comber, and one process of drawing. The same spinning process is used for both carded and combed yarn tests. Applicants may specify the percentage of comber waste to be removed, but if none is requested, the standard procedure of the laboratory will be followed.

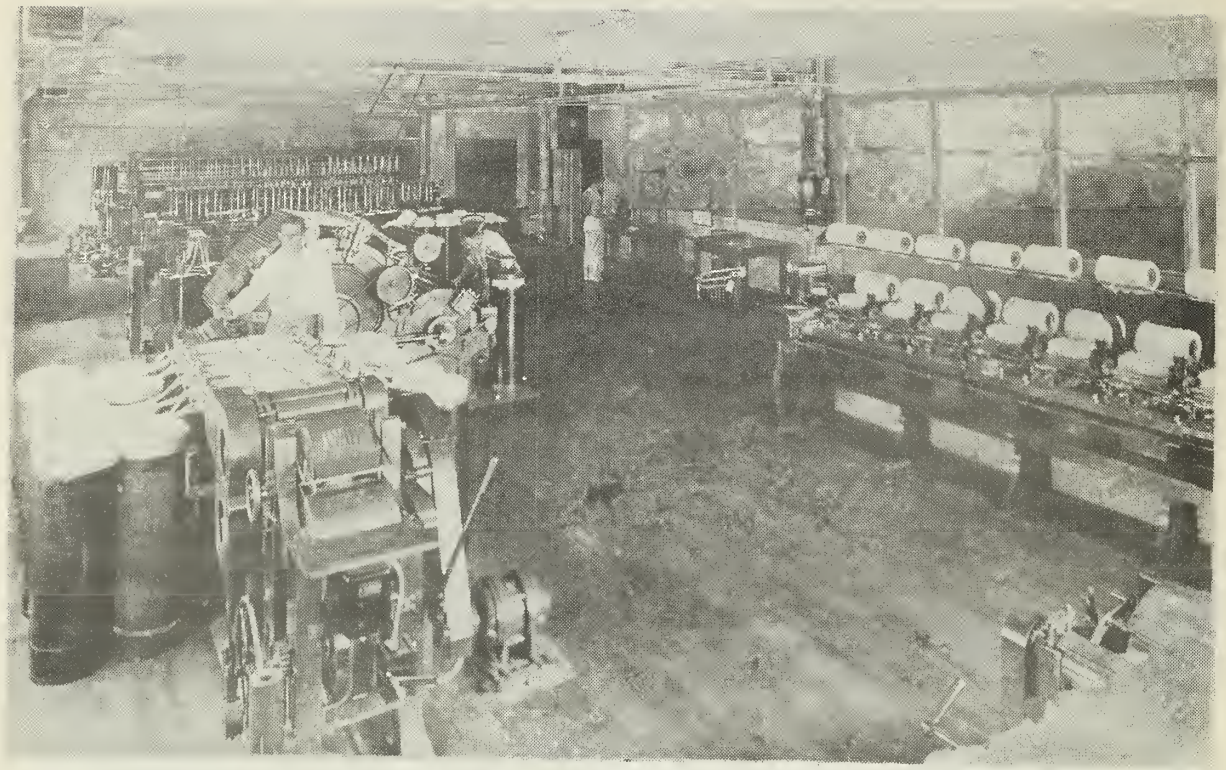

Figure 7.--General view of the processing equipment used in the card room at one of the cotton spinning laboratories. Shown on the right is a comber; in the left foreground a sliver lapper; and back of this machine a card, drawing frame, and roving frames.

When long staples--cottons having staple lengths above 1-1/4 inches--are processed, a 2-blade beater is substituted for the Kirschner or carding-type beater in the picker. Also, long staples are subjected to different carding actions, in that American-Egyptian and upland types above 1-1/4 inches in staple length are carded with a doffer speed of 4 r.p.m. For sea island cotton, the doffer speed is reduced still further, to 3 r.p.m. These doffer speeds result in the production of 3.6 pounds of 36-grain sliver per hour for long staple uplands and of 2.7 pounds of 32-grain sliver per hour for sea island. Since the card cylinder speed is kept constant at 166 r.p.m., these longer staples are subjected to considerably more carding action, which results in the removal of more material in the form of card waste. In addition to the above deviations from the standard procedure for handling short- and medium-staple cottons, these extra long-fibered cottons, which are usually spun into 60s, 80s, and 100s, are processed through a jack frame.

Three yarn numbers are spun for all tests to provide comprehensive data in terms of a relatively wide range. In order to be

able to interpret specific test results on the basis of research and other data accumulated over a period of years, certain yarn numbers have been adopted as standard. For carded yarns, 22s yarn is spun in all instances. A second number may be designated by the applicant from the following standard numbers; 14s, 36s, 44s, 50s, or 60s. The applicant may designate as the third number to be spun, any number within the spinnable range of the cotton.

For combed yarn, 60s is the standard yarn number spun in all instances. The applicant may designate either 80s or 100s as the second standard number. As the third number, any number within the spinnable range of the cotton may be designated by the applicant.

The standard numbers are spun with the optimum twist multiplier for the fiber length, but the applicant may designate any twist desired for the third number. The following tabulation shows the yarn numbers usually spun and the twist multipliers used for cotton of the various lengths as determined by the fibrograph method:

Fiber length	Yarn numbers spun			
Fibrograph upper half mean	Low	Medium	High	Twist Multiplier
Inches				
0.62 or below	14s	22s	36s	5.35
.63 to 66	14s	22s	36s	5.15
.67 to .70	14s	22s	36s	5.00
.71 to .74	14s	22s	36s	4.85
.75 to .78	22s	36s	44s	4.70
.79 to .82	22s	36s	44s	4.60
.83 to .86	22s	36s	50s	4.45
.87 to .89	22s	36s	50s	4.35
.90 to .93	22s	36s	50s	4.25
.94 to .97	22s	36s	60s	4.20
.98 to 1.01	22s	36s	60s	4.10
1.02 to 1.05	22s	36s	60s	4.05
1.06 to 1.09	22s	36s	60s	3.95
1.10 to 1.13	22s	36s	60s	3.90
1.14 to 1.16	22s	36s	60s	3.85
1.17 to 1.20	22s	36s	60s	3.80
1.21 to 1.24	22s	36s	60s	3.75
1.25 to 1.28	60s	80s	100s	3.70
1.29 to 1.32	60s	80s	100s	3.65

The spinning test reports show the following data: Grade and staple length classification of the cotton, upper half mean length, mean length, and uniformity ratio as determined by fibrograph, percentage of picker and card wastes broken down into the respective types of waste, comber wastes where combed tests are made, nep count in the card web, yarn skein strength, equivalent staple length, and yarn appearance grades. A summary of notes and observations made throughout the various stages of manufacture is also included. Where fiber tests have also been requested, an analysis is made of the spinning test results as related to the various fiber properties of the raw cotton. Yarn appearance boards for each yarn number spun are furnished with spinning test results.

In evaluating results of fiber and spinning tests, too much significance should not be attached to small differences shown for individual tests. In practical application, it should be remembered that a small difference in a single measurable property may be overshadowed by other properties. Conclusions, therefore, should be made only after consideration of all test results.

The results of tests conducted on a large number of lots of cotton provide the following bases for the evaluation of specific test results:

Grade and manufacturing waste. - Grade provides an indication of waste content of a sample of cotton. Long staples show greater percentages of picker and card waste than corresponding grades of shorter staple lengths, as they are subjected to a more thorough carding action when the doffer speed is reduced from 10-1/2 to 4 r.p.m. Although, for individual samples, the waste removed in processing is not always higher for the lower grades, past experience has shown the average relationship between grade and manufacturing waste to be approximately as follows:

Grade	Average percentages, picker and card waste	
	Medium and short staple Percent	Long staple Upland Percent
Good Middling	6.3	9.9
Strict Middling	7.2	10.9
Middling	8.0	11.9
Strict Low Middling	9.2	13.1
Low Middling	11.8	14.0
Strict Good Ordinary	14.0	(no data)
Good Ordinary	16.5	(no data)

In comparing these average grade figures with the picker and card waste data, it should be understood that variations from the averages for individual samples are attributable to the nature of the extraneous material present in the cotton, the characteristics of the fiber, and whether the grade designation was low because of poor color.

Nep count. - A desirable feature of any cotton is its relative freedom from neps, because they may be a source of trouble in manufacturing yarns and fabrics. The occurrence of neps in appreciable numbers detracts from the appearance of these products. This is especially true when they are to be dyed or printed, as the neps absorb dyes differently and appear as spots on the material. When the nep count in the card web is high the cotton is likely to produce rough and neppy yarns, as there is a relationship between yarn appearance and nep count. Excessive neppiness, therefore, limits the uses for which the cotton is suitable. The following adjective descriptions will serve to classify cottons from the standpoint of neppiness:

Number of neps per 100 square inches of card web	
1 - 15	Low
16 - 25	Average
26 - 40	High
Above 40	Very high

Waste and nep count. (27 and 27a) - This test affords a means for comparing the relative wastiness and neppiness of 5- or 50-pound samples of cotton in the event it is not desired to make complete spinning tests. The cotton is processed through the pickers and card for cleaning and waste removal in the same manner as for spinning tests. The percentage of waste at each cleaning element of each cleaning machine is reported, as well as the average nep count per 100 square inches of card web based on five determinations. These tests are discussed in the preceding paragraphs entitled "Grade and manufacturing waste" and "Nep count" under the general heading, "Processing Tests and Their Evaluations."

Yarn strength. - Probably the most important and most reliable single index of spinning quality is the yarn strength. An automatic reel, having a circumference of 1-1/2 yards, is used to form skeins for the test. Each of these skeins is composed of 120 yards of yarn that is obtained from a bobbin by 80 revolutions of the reel. After the skeins have been exposed for 4 hours or more to standard atmospheric conditions, they are broken on a pendulum-type tester similar to that shown in figure 8. A minimum of 25 skeins is tested to obtain the skein strength value reported for each yarn number in the test. In the yarn testing laboratory, the actual breaking strength of each skein is then recorded, along with the actual yarn number that is

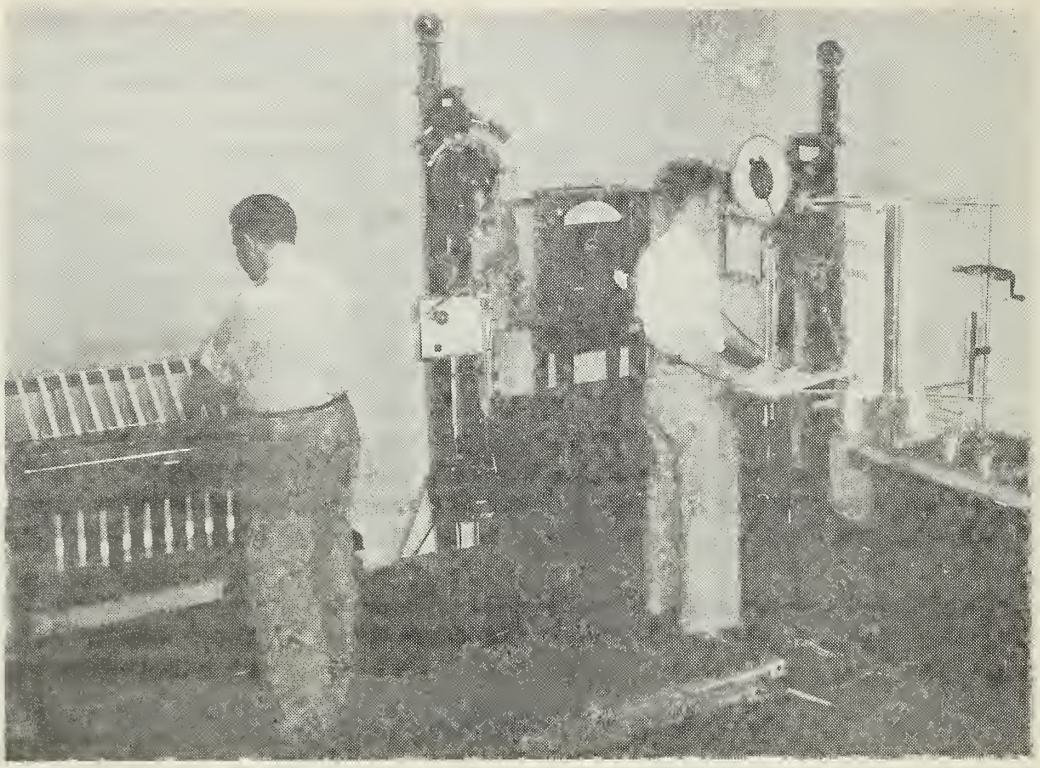

Figure 8.--Laboratory equipment used for determining yarn strength. Shown from left to right is a reel for preparing skeins; single strand cord-tester, cabinet containing sizing quadrant for determining actual yarn number; pendulum-type tester; and a skein conditioning rack.

obtained by weighing the broken skein on a yarn-numbering quadrant. These actual strength and yarn number data are used to calculate the breaking strength reported for each yarn number spun.

Yarn strengths of at least average are desirable, as they not only increase the range of usefulness of a given cotton but are also an indication of good spinning and weaving performance. Without regard to staple length, the skein strength for some standard numbers of carded yarn as spun on long draft equipment may be classified as follows:

Skein strength of carded yarn

	14s Pounds	22s Pounds	36s Pounds	50s Pounds	60s Pounds
Excellent	Above 195	Above 119	Above 70	Above 45	Above 35
Very good	180 - 195	109 - 119	64 - 70	40 - 45	32 - 35
Average	165 - 179	100 - 108	56 - 63	35 - 39	27 - 31
Fair	155 - 164	92 - 99	50 - 55	31 - 34	23 - 26
Poor	Below 155	Below 92	Below 50	Below 31	Below 23

The combing process contributes significantly to yarn strength, although the process is frequently used primarily for the purpose of improving yarn appearance. Because of the higher range in yarn strength obtained from combed yarns when spun from long staple American upland cotton, a different basis from that used for carded yarns is required for classifying them. The following tabulation is presented as a basis for classifying combed yarn strengths obtained from three standard laboratory numbers:

Skein strength of combed yarns

	60s Pounds	80s Pounds	100s Pounds
Excellent	Above 48	Above 33	Above 24
Very good	44 - 48	30 - 33	22 - 24
Average	39 - 43	26 - 29	19 - 21
Fair	34 - 38	22 - 25	16 - 18
Poor	Below 34	Below 22	Below 16

Yarn skein strength results reported are based on an average of 25 breaks, which have been found necessary for reliable results. In general, the strength figures shown are higher than those obtained in commercial mills. This is explained by the fact that twist multipliers used in spinning yarns at the laboratories are selected to give the highest yarn strengths obtainable from each individual cotton tested, that it is necessary to keep the laboratory processing machinery in excellent condition at all times in order to provide test results that are strictly comparable, and, that laboratory results are to a large extent based on yarns manufactured from pure varieties of cotton. In other words, the degree of precision which is necessary for laboratory testing may not be economically feasible in a commercial textile mill.

Equivalent staple length. The equivalent staple length as reported in connection with spinning tests provides a means for comparing yarn strengths obtained in the testing of a specific sample with those of the general average of cotton. The equivalent staple length reported in each instance is the staple length generally required to produce the yarn strength obtained for that particular sample. When the length shown for a given cotton is greater than the classer's staple length designation, then that particular sample is above average with respect to yarn strength for its staple length. If, on the other hand, the equivalent staple length is lower than the classer's length, the reverse is true. For example, a given test sample of cotton classed as 1 inch in staple length might have yarns strengths of 113 pounds for 22s, 63 pounds for 36s, and 41 pounds for 50s. In such a case, the equivalent staple length would be 1-1/16 inches because, on the average, cottons classed as 1-1/16 inches in staple length produce yarns of those respective strengths.

Equivalent staple length is, therefore, merely another way of expressing yarn strength and it is not a complete measure of spinning value. Although yarn strength is one of the important factors determining spinning value, other factors, such as percentage of waste in manufacturing, rate at which the cotton can be processed through the various textile machines, yarn appearance, and bleaching and dyeing properties, affect the value of cotton to the textile manufacturer. The relative importance of these factors varies with the product for which the yarn is used. For some products, such as thread and tire cord, yarn strength is highly important, whereas for many other products yarn strength above the average is not so important as are some of the other factors. This being the case, a cotton having an equivalent staple length significantly greater than the classer's staple length designation would for certain uses, justify a premium over cotton of the same staple length producing yarns of average strength, but for other uses where yarn strength above average is not required, a premium might not be justified.

Attention is also called to the fact that the equivalent staple length reported in any given case is applicable only within the range of yarn numbers that were spun. When the equivalent staple length is materially longer than the classer's length designation, the performance of the cotton may not equal that of cottons having the actual staple length indicated when manufactured into finer yarn numbers. This is because other fiber properties associated with longer fibers, notably fiber fineness, become increasingly important as the finer yarn numbers are spun.

The average long-draft carded-yarn skein strengths, obtained in the laboratories from different staple lengths, are as follows:

Classer's staple length	Yarn numbers					
	14s	22s	36s	44s	50s	60s
Inches	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
3/4	135.3	80.3	42.5	-	-	-
25/32	140.4	83.6	44.6	-	-	-
13/16	145.5	86.8	46.6	35.0	28.6	-
27/32	150.6	90.1	48.7	36.7	30.2	-
7/8	155.7	93.4	50.7	38.4	31.7	23.4
29/32	160.8	96.7	52.8	40.1	33.2	24.7
15/16	165.9	100.0	54.9	41.8	34.7	26.0
31/32	171.0	103.3	56.9	43.5	36.2	27.2
1	176.0	106.6	59.0	45.2	37.8	28.5
1-1/32	181.1	109.8	61.0	47.0	39.3	29.8
1-1/16	186.2	113.1	63.1	48.7	40.8	31.1
1-3/32	191.3	116.4	65.2	50.4	42.3	32.4
1-1/8	196.4	119.7	67.2	52.1	43.8	33.7
1-5/32	201.5	123.0	69.3	53.8	45.4	35.0
1-3/16	206.6	126.3	71.3	55.5	46.9	36.2
1-7/32	211.6	129.6	73.4	57.2	48.4	37.5
1-1/4	216.7	132.8	75.4	58.9	49.9	38.8
1-9/32	221.8	136.1	77.5	60.6	51.4	40.1
1-5/16	226.9	139.4	79.6	62.3	53.0	41.4

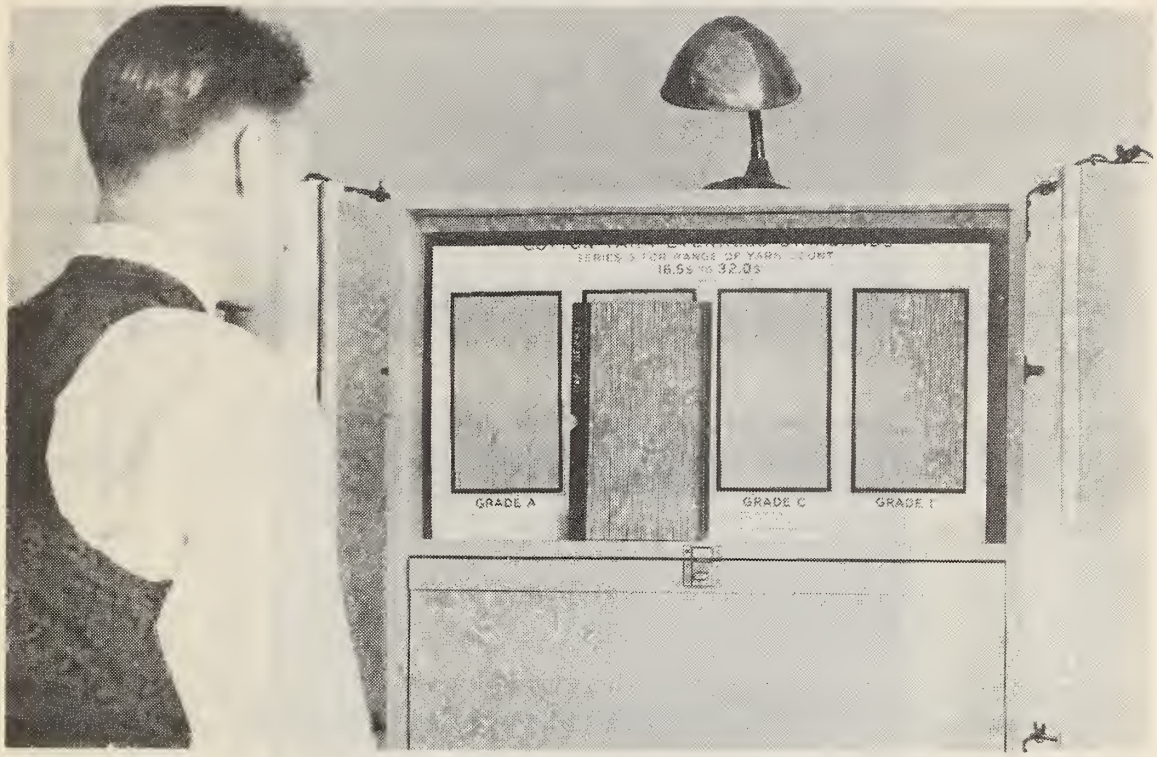

Figure 9.--Technician grading a yarn board against a cotton yarn-appearance standard. The standards are fitted into a specially designed cabinet equipped with lamps and reflectors to facilitate accurate grading.

Yarn appearance. - The appearance of the yarn in many types of woven or knitted materials is a very important quality factor, and is expressed in these tests through the medium of yarn appearance grades developed in the laboratories of the Cotton Branch and adopted as standards by the American Society for Testing Materials (See figures 9 and 10). The following descriptive designations will be helpful in evaluating the results reported:

Yarn appearance	
Grade	
A	Excellent
B+	Very good
B	Good
C+	Average
C	Fair
D+	Poor
D and below	Very poor

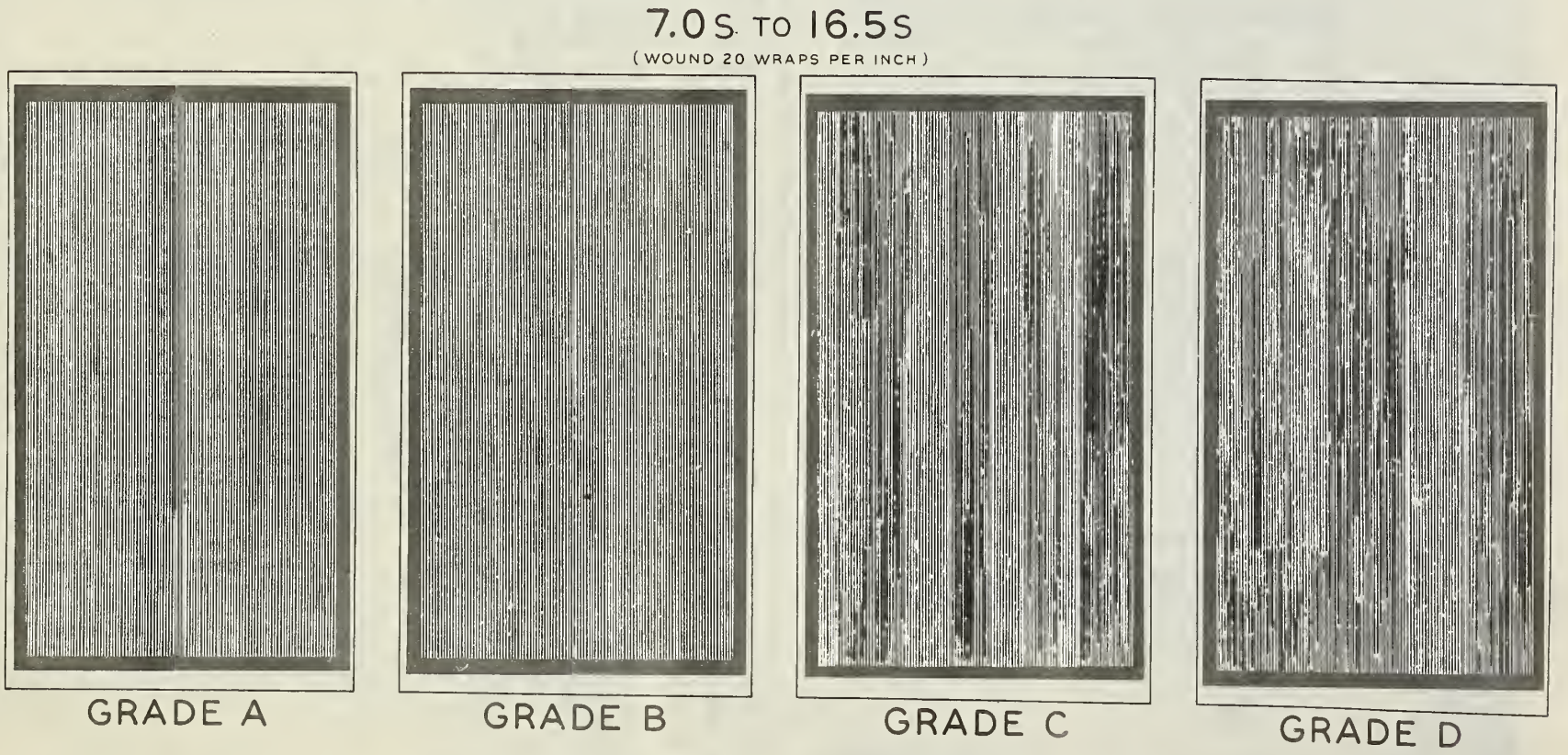

Figure 10.--One of the series of 5 standards used to grade yarns for appearance (about 1/3 actual size). Yarns wound on boards suitable for making visual examinations or for direct comparisons with the standards are sent to applicants as a part of each spinning test report.

The fabric strength test (29) is conducted according to the specifications of the American Society for Testing Materials for the grab test. The applicant should, therefore, furnish a sample 1-yard square and including at least one selvage. From the piece submitted, five fabric specimens measuring 4 by 6 inches each, are cut from areas that will be representative of the warp, and a similar number of samples are taken to represent a relatively wide range of the filling. These samples are tested and data reported for the average warp and filling strengths.

Fabric weaving and testing. (30) - This test is offered only as a supplement to spinning tests, and thus is only available with a spinning test. It includes the warping and slashing of yarn, and the weaving of a fabric 11-3/4 inches wide. A standard sheeting construction may be specified by the applicant; otherwise the fabric will be woven in accordance with the following nominal specifications:

Construction . . .	68 x 72
Warp	21s
Filling	23.6s
Weight	4.9 oz. per yard

Results reported for this test show the actual and nominal weight of the fabrics, warp and filling counts, and the results of fabric strength warpwise and fillingwise in accordance with the methods outlined for item (29).

Yarn twist test. (33 and 33a) - One yarn number is spun with six twist multipliers from a sample of raw cotton, picker lap, sliver, or roving as a basis for determining the twist multiplier that will result in yarns having the greatest skein strength. The results obtained from the test also show the extent to which yarn strength falls off when somewhat more or less than the optimum twist is used. The test is made on any yarn number between 14s and 100s that is within the spinnable range of the cotton, and the results are based on 25 skein breaks for each of the 6 twists spun.

Spinning and testing additional yarn numbers. (20) - In the event the three yarn numbers provided in connection with spinning tests are not adequate for the specific purposes of an applicant, provision is made for the spinning of any extra numbers desired so long as they are within the spinnable range of the cotton. Yarn skein strength and appearance grade are included in this test.

Plied yarn. (21) - This test, which is made only in connection with spinning tests, includes the twisting and the testing of 2-ply or 3-ply yarns. The yarn strength is determined and reported in accordance with the specifications of the American Society for Testing Materials.

Tire cord test. (22) - This test is offered only in conjunction with and as a supplement to a spinning test. Although it is fully recognized that 23s/5/3 tire cord offered in this test is no longer a standard construction, and that the tire cord manufactured is not subject to special stretching, stabilizing, or other treatments in accordance with present practices of many commercial producers, it does afford a means of evaluating the results obtained for different cottons in plied and cabled materials. Furthermore, the basic data available with respect to this construction provide a basis for evaluating results for individual tests. These tests are conducted according to the standard procedures adopted by the laboratories. Other cord constructions are available under item (22a) of the regulations.

Cord test. (22a) - This is offered only in conjunction with and as a supplement to a spinning test. The test affords a convenient medium for studying the results obtained for cottons manufactured into various plied and cabled constructions. Because of limitations in types of manufacturing and testing equipment at the laboratories, it is not feasible to make cords coarser than the equivalent of number 1 singles. These tests are conducted according to the standard laboratory procedures.

Furnishing yarn to applicant. (34) - In those instances where a relatively small quantity of yarn is desired for further study by the applicant, it may be obtained by requesting item (34). The yarn is wound on parallel paper tubes and charged for on a poundage basis. Yarn, either carded or combed, is supplied only in connection with spinning tests (items 11 through 19a) and, when it is requested, the sample of cotton submitted for the spinning test must be larger than the usual 5 or 8-pound samples, in proportion to the quantity of yarn needed.

Furnishing additional yarn boards. (35) - Only one yarn appearance board is furnished for each yarn number spun in connection with spinning tests (11 through 19a), (20), and (23). These yarn boards are suitable for use in grading yarns in accordance with the cotton yarn appearance standards, or for making other comparisons or inspections. When more than one yarn board is needed, they may be obtained at a small additional cost.

Other Tests

Yarn skein strength, size, and appearance grade. (23) - This test affords a means for a cotton manufacturer to compare yarns processed in his own mill from cottons submitted for laboratory spinning tests with yarns processed at the laboratories of the Cotton Branch. The test includes the reeling, conditioning, breaking, and

sizing of 25 skeins from the bobbins submitted as representative of a given lot of yarn, and the preparation and gracing of one yarn appearance board. The test report furnished includes average skein strength, average yarn count, appearance grade, and one yarn board.

Moscrop single strand yarn strength test. (24) - The Moscrop tester is a single strand strength-testing machine that accomodates 6 bobbins at one time. It automatically threads and breaks the yarn and records the strength autographically on a special recording chart for a minimum of 36 successive 10-inch lengths from each bobbin. The average observed breaking strength for each bobbin, and for the lot, is reported in ounces. Where detailed analyses of the individual breaks are desired, copies of the chart on which the breaks are automatically recorded will be furnished when item (24a) is requested along with the Moscrop test. The actual size of the yarn, obtained by reeling and sizing one skein from each of the 6 bobbins, is also reported.

Shirley analyzer test. (25 and 26) - In this test, a weighed sample of lint, mill waste, or linters is fed into the machine and an almost perfect separation of lint and trash is made (See figure 11). The report furnished shows the weight fed, weight of lint delivered, weight of visible foreign matter, weight of invisible loss, and percent of nonlint, which is the total of visible and invisible loss. Nonlint removed by the Shirley analyzer is distinguished from total picker and card waste by the fact that practically no fiber is included as in the usual waste from mill cleaning machines. Since not only lint but various mill wastes can be analyzed, the test is useful for a number of research purposes. If specifically requested, the cleaned lint and the trash removed are returned to the applicant for his inspection and use.

Based on tests made on bales used in the white grade standards, the following scale has been established to represent percentages of nonlint removed by the Shirley analyzer from different grades:

Grade	Nonlint Percentage by weight
Strict Good Middling	2.0
Good Middling	2.4
Strict Middling	2.9
Middling	3.7
Strict Low Middling	5.1
Low Middling	7.6
Strict Good Ordinary	11.0
Good Ordinary	17.0

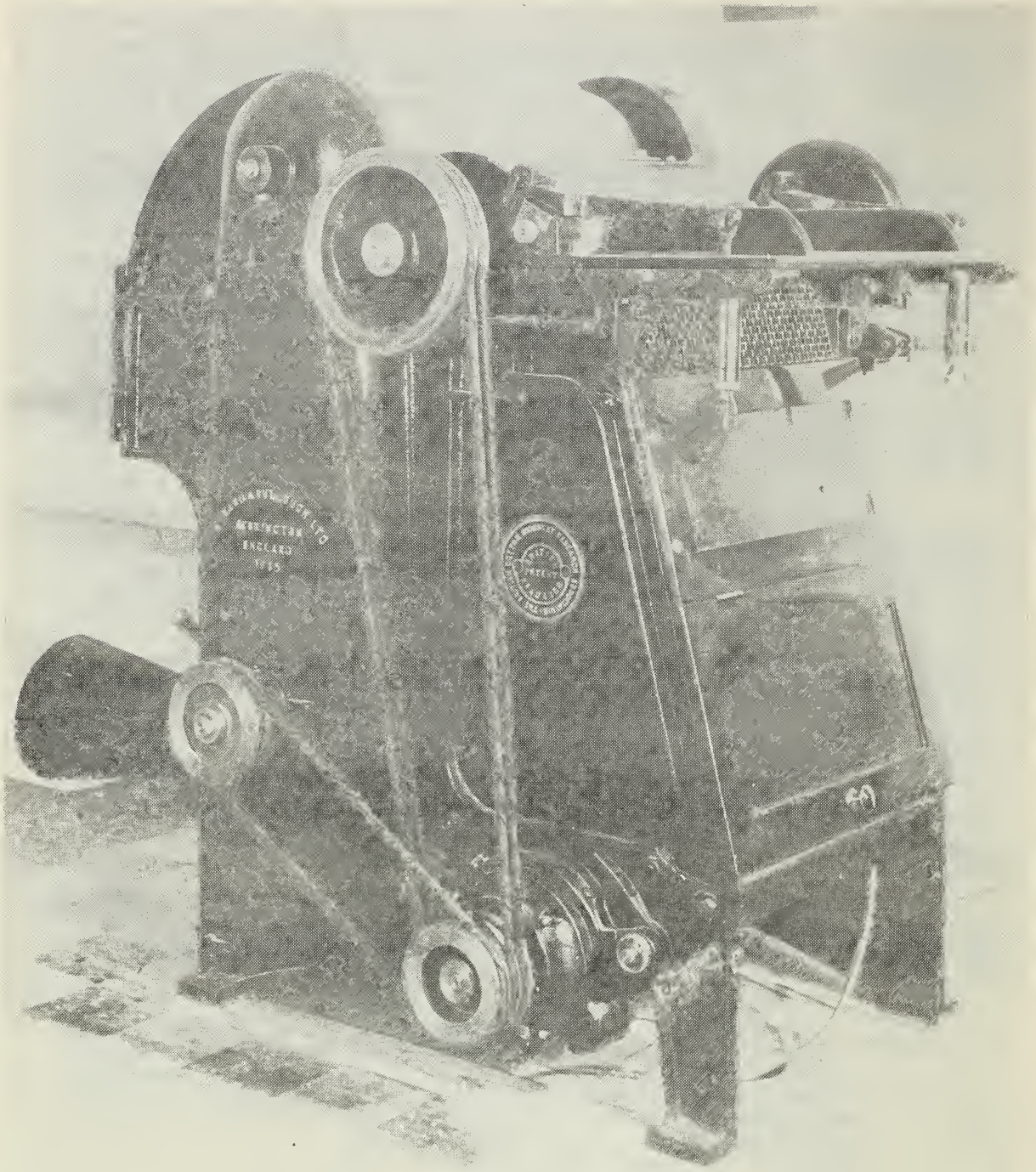

Figure 11.--Shirley analyzer used for separating foreign matter from fibers in samples of raw cotton, manufacturing waste, or purified cotton.

In the grade standards, only the surface of each cotton sample represents the grade. Nevertheless, the average percentages by weight of nonlint in bales of the original 1936 and 1946 standards agree sufficiently to provide a good basis for comparison. The foregoing tabulation is derived from a smoothed curve drawn on the basis of these data. Differences in results obtained for individual samples and percentages shown may be caused by two things: First, there are intentional allowances for variations in trash content among bales in each standard grade (to offset differences in color and provide a range for the grade) that may amount to an overlap, particularly in the higher grades. Second, these figures are based on weight and do not take into consideration the nature of trash, which is sometimes quite as important as weight in determining the grade designation.

Determination of moisture content. (36) - Determinations of the moisture content of samples of raw cotton, cotton stock at various manufacturing stages, cotton yarn, and various types of manufacturing waste are made. Results reported for this test show wet weight, dry weight, loss in weight, and percentage regain for each sample.

Extra copies of test report and data sheets (31 and 32) are available at the prices listed in the schedule of tests.

Relationship of Test Data to Published Reports

Users of the testing service are placed on a mailing list to receive publications, issued from time to time, dealing with various research studies and reporting test results for the improved varieties of cotton grown and tested each year. The data reported in these publications provide a basis for evaluating test results and for comparing the specific cottons submitted for test with the various improved varieties.